The Effects of a First Year Engineering Class Using the SCALE-Up Method on Student Retention and Subsequent Student Pass Rates

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Abstract

Due to the increased demand for engineers, the University of Texas at Arlington (UTA) created a new, first year engineering class using the Student-Centered Active Learning Environment with Upside-down Pedagogies (SCALE-Up) method to specifically address engineering student retention by encouraging student persistence and success throughout their academic career. Since UTA enjoys a very diverse student population with varying learning styles, socio-economic backgrounds, and prior knowledge and preparation, the SCALE-Up method was chosen due to its reliance on problem-based, active learning strategies, peer instruction through teamwork, and peer leaders within the classroom. After two and a half years of implementation of this class, known as ENGR 1300 – Engineering Problem Solving, this paper will explore the first year and second year engineering retention rates. This comparison will show that engineering retention rates have increased since ENGR 1300 was implemented. Further, this paper will show this increase occurs across multiple student type groups, provided that the student take ENGR 1300 in their first semester. Finally, to assess the positive effects of the new class, this paper will show that the pass rates of three subsequent mechanical engineering classes, Statics, Dynamics, and Strength of Materials, increased after ENGR 1300 was implemented.

1. Introduction

Two and a half years ago, UTA replaced a one credit, traditionally-styled introduction to engineering class with a course designed to aid in increasing engineering student retention and persistence. This new course, known as ENGR 1300 – Engineering Problem Solving, seeks to strengthen student's critical problem solving and communication skills that are necessary for their future success in subsequent engineering classes, provided they are at least concurrently enrolled in Pre-Calculus. In order to aid all students, regardless of learning style, socio-economic background, or prior knowledge, this class uses the Student-Centered Active Learning Environment with Upside-down Pedagogies (SCALE-Up) method. This method, originally developed at NC State [1] and utilized in many universities [2], relies on creating a highly active and collaborative learning environment focusing on solving problems in contrast to traditional lecture styles. Also, student group interaction and student to instructor interaction increase in order to foster more individualized attention. This method, along with other active learning strategies, has also been shown to increase success rates for all students, including underrepresented minority groups [3].

The effect that this method has on pass rates in ENGR 1300 across many student groups has been demonstrated in previous works [4-6]. However, in this paper, we will demonstrate increased first and second year retention rates in the college of engineering as well as increased passing rates in key follow-up courses in the Mechanical and Aerospace Engineering department.

2. Methodology

The complete discussion of how this methodology has been specifically in ENGR 1300 may be found in this work [4]; however, for ease of discussion, a brief summary has been included here.

To implement the SCALE-UP method into the curriculum, several modifications of the existing space were necessary. First, a new, SCALE-Up classroom was constructed. Students are arranged around circular tables in teams of three, and marker boards are mounted around the room. This arrangement allows students to solve problems together, fostering peer instruction, even in large enrollment sections. The arrangement also allows the professor to easily move among the students as they work on solving problems. This physical arrangement allows more one-on-one instructor interaction, which is essential for ENGR 1300 because each section has up to 99 students enrolled.

The second key strategy was the hiring of upperclassmen to act as in-class assistants in order to reduce the student-to-teacher ratio. Not only does this create more individualized instruction, but also, students are often more comfortable asking the assistants rather than their instructor. The

assistants also conduct free tutoring sessions in the evenings where they help the students by guiding them through the problem-solving process. This addition aids in increased coverage of differing student schedules as well as alleviating over-taxed office hours.

Most importantly, the SCALE-Up methodology focuses on active learning rather than traditional lectures. Traditional lectures and passive learning techniques have shown to be decreasingly effective in student success and knowledge retention [3]. This method utilizes mini-lectures, usually no more than 10 minutes at a time, in order to leave time to focus on students solving problems in class togheter. Students work in their teams around the marker boards solving real-world engineering problems, rather than simply relying on notes and examples from the professor.

3. Results and discussion

3.1 Overall Engineering Retention

The ultimate goal for implementing ENGR 1300 and the SCALE-Up method was to increase engineering student retention. Up until this point, results have been reported on the increasing pass rates of students, regardless of student group characteristics [4-6]. Now that ENGR 1300 has been implemented for over two years, we can explore first and second year retention data. First, we will consider overall engineering student retention, as shown in Figure 1.

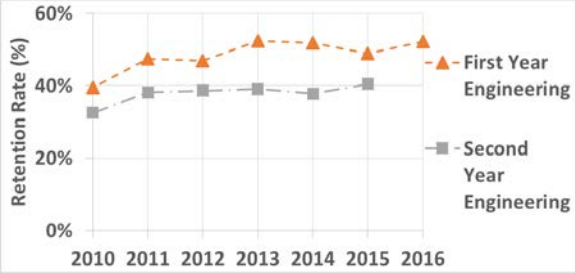

Figure 1. Overall engineering retention rates, regardless if students took ENGR 1300 in their first semester. The years shown are the Fall cohorts of students.

In Figure 1, we track first year, and second year retention rates within the college of engineering. It should be noted that ENGR 1300's first cohort was Fall 2015 and was restricted to 72 students per section. Then, for Fall 2016, the enrollment grew to 99 students per section. Also, it should be noted that not all students admitted in the fall semesters take ENGR 1300 in their first semester, due to co-requisite requirements, space limitation, and lack of participation by one of the departments in the college.

With these factors considered, there is a slight increase in both first and second year engineering retention, except for the first year retention of the first fall cohort, Fall 2015. This is significant because, as explained in [4], ENGR 1300 is a technically rigorous course that replaced a non-rigorous one credit course. In its original planning, the goal was to increase engineering student retention by ensuring that engineering students were better prepared for their subsequent engineering courses. The second year engineering retention data best illustrates this goal. As can be seen in Figure 1, students in the Fall 2015 cohort not only were retained at a higher rate than in previous cohorts, but even more importantly the difference between the first and second year was the smallest in recent years. While Figure 1 does illustrate a slight increase in retention, we must evaluate the same data on whether a student took ENGR 1300 in their first semester or not, if we are to see the true difference ENGR 1300 has made.

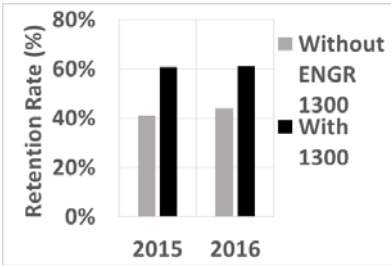

Figure 2. First year engineering retention rates considering whether students took ENGR 1300 in their first semester

In Figure 2, we examine the first year engineering retention data from the Fall 2015 and Fall 2016 cohorts only, since ENGR 1300 was first implemented in Fall 2015. As can clearly be seen, first year engineering retention is drastically higher if students take ENGR 1300 in their first semester, showing around a 48% improvement in retention, or nearly 20 percentage points higher.

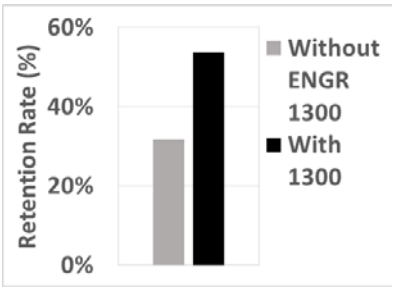

Figure 3. Second year engineering retention rates for the Fall 2015 cohort considering whether students took ENGR 1300 in their first semester

As mentioned previously, to fully see ENGR 1300's effect on retention, the second year retention rates can be seen in Figure 3. If students took ENGR 1300 in their first semester, they are being retained nearly 22 percentage points higher, which is an approximately 70% improvement, than those who do not take ENGR 1300 in their first semester. Clearly, the SCALE-Up method in ENGR 1300 has greatly improved retention within the

college of engineering at UTA and has helped students persist in their degrees beyond their first semester.

3.2 Admission Effect

Since UTA receives many transfer students and new freshman with various levels of preparation, exploration of the overall retention data is not thorough enough to evaluate ENGR 1300's effectiveness at for all UTA engineering students. Since UTA's goal is to aid all of our diverse student population, we must evaluate the retention numbers amongst our new freshman and new transfer students to see if there is any biasing in the data.

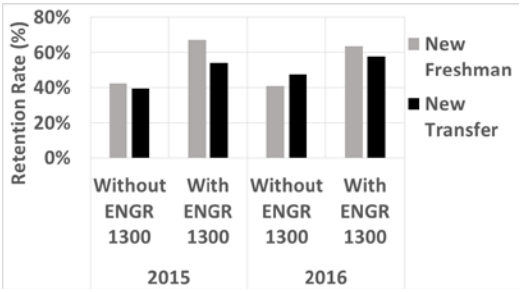

Figure 4. First year engineering retention rates considering whether students took ENGR 1300 in their first semester and their admission pathway

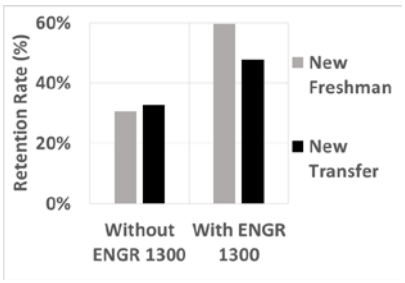

Figure 5. Second year engineering retention rates for the Fall 2015 cohort considering whether students took ENGR 1300 in their first semester and their admission pathway

In Figure 4 and Figure 5, the first year and second year engineering retention data for new freshman and new transfer students are shown, respectively. If students take ENGR 1300 in their first semester, there is a profound improvement in retention for students of both admission types. However, it should be noted that with few exceptions, overall, new freshman benefit more greatly from having ENGR 1300 in their first semester. Many factors could influence this fact. More information about our transfer population is needed to make a full evaluation, including work schedules, family obligations, and other considerations. But, the data shows that ENGR 1300 vastly improves student persistence.

3.3 Ethnicity Effect

UTA, being an HSI university, also enjoys an ethnically diverse student body. One of the strengths of the SCALE-Up method is that it has been shown to be effective with many underrepresented minorities [3]. Therefore, identifying difference in retention rates amongst our many ethnic groups is essential to UTA's academic goals.

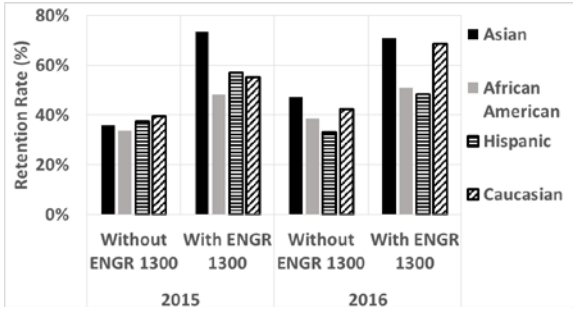

Figure 6. First year engineering retention rates considering whether students took ENGR 1300 in their first semester and their ethnicity

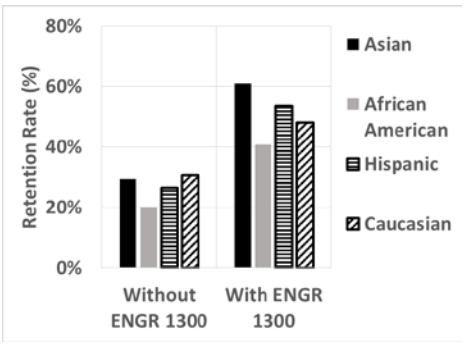

Figure 7. Second year engineering retention rates for the Fall 2015 cohort considering whether students took ENGR 1300 in their first semester and their ethnicity

In Figure 6 and Figure 7, the differences in first and second year engineering retention data for UTA's major ethnic groups. As can clearly be seen, all groups enjoy a large increase in retention rate if they take ENGR 1300 in their first semester. In fact, UTA is retaining our Hispanic population better in their second year than most of our other ethnic groups, which is very important for our UTA's student population. However, in Fall 2016, though there is improvement across the board, our underrepresented minorities seem to have experienced a setback. In order to address and explore this fact, we will need to get more background information about those groups. But, as illustrated, all minority groups see a drastic improvement in retention, further fulfilling the goals of the university.

3.4 Subsequent Class Pass Rates

Finally, to further assess the applicability and strengths of the SCALE-Up method in ENGR 1300, another objective was to assess student's ability to pass their subsequent

engineering courses. This fact will illustrate student's preparation and persistence in their path to becoming an engineer.

UTA's largest engineering department, the Mechanical and Aerospace Engineering department, set ENGR 1300 as a pre-requisite for three of their critical courses, which are Statics, Dynamics, and Solid Mechanics. Then, the pass rates were compared before ENGR 1300's implementation and after, evaluating back to Fall 2013. The results were compiled and are shown in Figure 8.

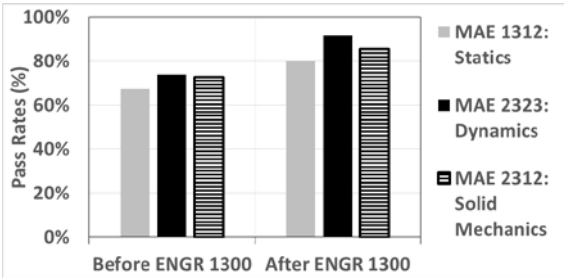

Figure 8. Subsequent mechanical and aerospace engineering class pass rates before and after ENGR 1300 was implemented

As can be seen, student pass rates have significantly increased in these three difficult courses after ENGR 1300's implementation. In fact, Statics and Solid Mechanics passing rates increased by 13 percentage points (an improvement of 19% and 18%, respectively). Dynamics increased by 18 percentage points, an improvement of 24%. These improvements are truly encouraging considering that Pre-Calculus is the co-requisite for ENGR 1300. Therefore, the higher level math that appears in these courses are not addressed in ENGR 1300. The increase in these pass rates can be attributed to ENGR 1300's reinforcement of problem solving and critical thinking skills. With these increased pass rates, ENGR 1300 and the SCALE-Up method has truly helped UTA's students.

4. Conclusion and Future Work

In conclusion, ENGR 1300, utilizing the SCALE-Up method, has shown to be effective in increasing first and second year engineering student retention rates. Further, increases has been shown regardless of admission status or ethnicity, which is very important to UTA's mission. This fact can also be seen in increasing pass rates in difficult subsequent classes in the Mechanical and Aerospace Engineering department. In further studies, more personal information is needed to assess why some student groups and transfer students seem to enjoy slightly less improvement.

Acknowledgement

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References

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